XXIII. *On the Water-Barometer erected in the Hall of the Royal Society. By* J. F. DANIELL, *Esq. F.R.S. Professor of Chemistry in King's College, London.*

Read June 21, 1832.

I HAVE for some time entertained an opinion, in common with some others who have turned their attention to the subject, that a good series of observations with a Water-Barometer, accurately constructed, might throw some light upon several important points of physical science: amongst others, upon the tides of the atmosphere; the horary oscillations of the counterpoising column; the ascending and descending rate of its greater oscillations; and the tension of vapour at different atmospheric temperatures. I have sought in vain in various scientific works, and in the Transactions of Philosophical Societies, for the record of any such observations, or for a description of an instrument calculated to afford the required information with anything approaching to precision. In the first volume of the History of the French Academy of Sciences, a cursory reference is made, in the following words, to some experiments of M. MARIOTTE upon the subject, of which no particulars appear to have been preserved. "Le même M. MARIOTTE fit aussi à l'observatoire des experiences sur le baromètre ordinaire à mercure comparé au baromètre à eau. Dans l'un le mercure s'elèva à 28 pouces, et dans l'autre l'eau fut à 31 pieds $\frac{1}{3}$. Cequi donne le rapport du mercure à l'eau de $13\frac{1}{2}$ à 1." Histoire de l'Académie, tom. i. p. 234.

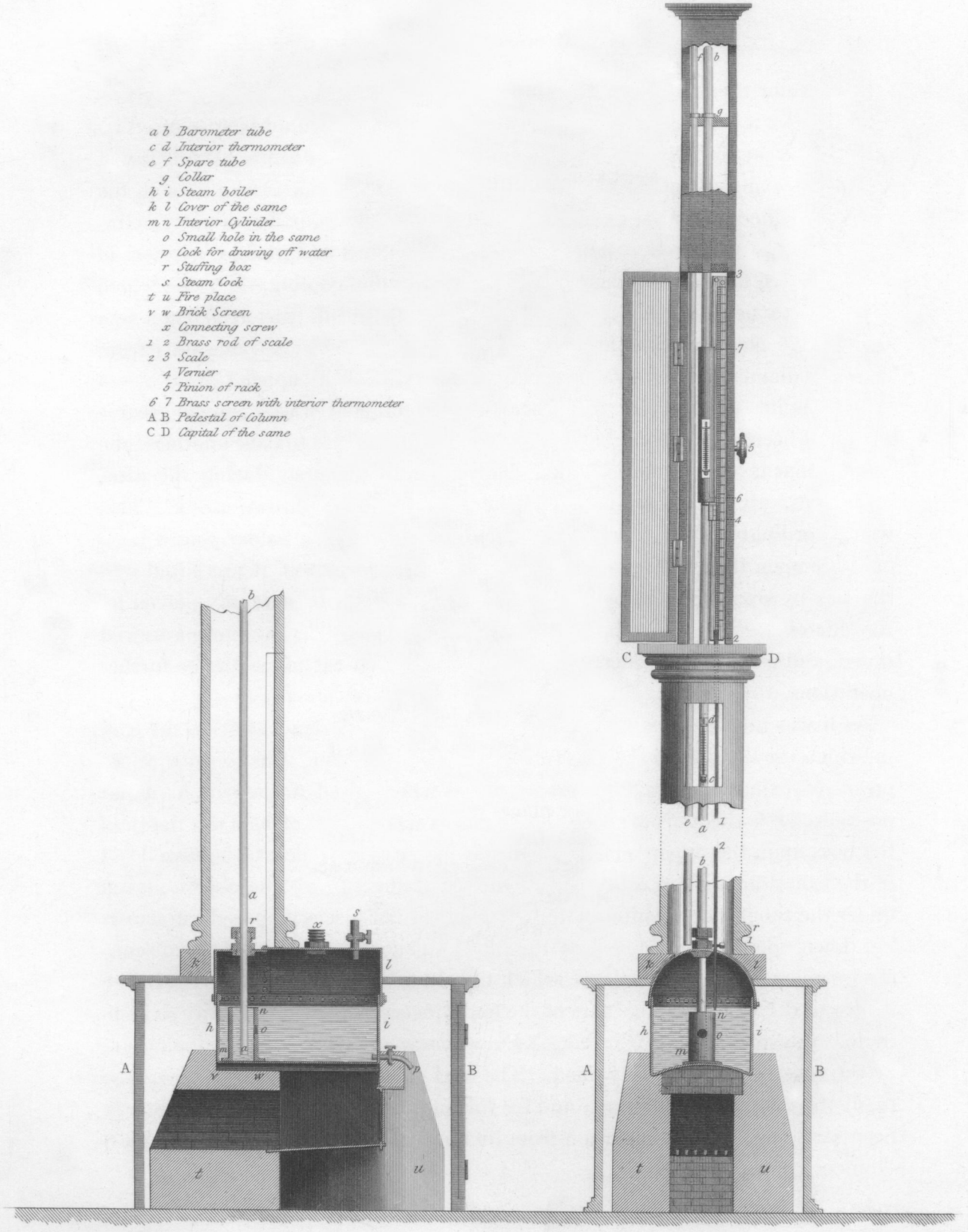
It also appears that OTTO GURICKE constructed a philosophical toy* for the amusement of himself and friends, upon the principle of the water-barometer;

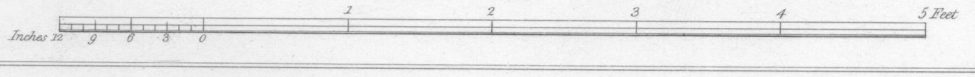
* It consisted of a tube above thirty feet, rising along the wall, and terminated by a tall and rather wide tube hermetically sealed, containing a toy of the shape of a man. The whole being filled with water and set in a bason on the ground, the column of liquid settled to the proper altitude, and left the toy floating on its surface; but all the lower part of the tube being concealed under the wainscoting, the little image made its appearance only in fine weather. To this whimsical contrivance he gave the name of *Anemoscope* or *Semper Vivum*.

but the column of water probably in this, as in all the other instances which I have met with, was raised by the imperfect rarefaction of the air in the tube above it, or by filling with water a metallic tube, of sufficient length, cemented to a glass one at its upper extremity, and fitted with a stop-cock at each end; so that when full the upper one might be closed and the lower opened, when the water would fall till it afforded an equipoise to the pressure of the atmosphere. The imperfections of such an instrument, it is quite clear, would render it totally unfit for the delicate investigations required in the present state of science; as, to render the observations of any value, it is absolutely necessary that the water should be thoroughly purged of air, by boiling, and its insinuation or reabsorption effectually guarded against. I was convinced that the only chance of securing these two necessary ends, was to form the whole length of tube of one piece of glass, and to boil the water in it, as is done with mercury in the common barometer. The practical difficulties which opposed themselves to such a construction long appeared to me insurmountable; but I at length contrived a plan for the purpose, which, having been honoured with the approval of the late Meteorological Committee of this Society, was ordered to be carried into execution by the President and Council.

The first object was to procure a glass tube of the proper diameter, and of sufficient length for the purpose. Messrs. Pellatt and Co., of the Falcon Glass House, very obligingly consented, upon application, to permit the trial to be made at their works; such an undertaking never having been before attempted. Accordingly, a very strong packing-case was prepared of one inch-and a-half deal, forty feet long, five inches wide, and four inches deep, inside measure; with a cover of the same thickness to screw down upon it. This was carried to the glass-house, and being laid in the yard with its cover off, small pieces of wood were placed across its bottom, at about one-foot intervals. The only instructions given to the workman were to make a tube of the length of the box, which should not be less than half an inch internal diameter, and as equal throughout its length as possible; and the manual dexterity with which he proceeded to effect this was well worthy of admiration. Having collected the glass at the end of his tube, and blown the cavity, a boy attached another iron with a small lump of hot glass to the opposite extremity of the mass, and drew the tube out by walking away to the required distance.

a b Barometer tube
c d Interior thermometer
e f Spare tube
g Collar
h i Steam boiler
k l Cover of the same
m n Interior Cylinder
o Small hole in the same
p Cock for drawing off water
r Stuffing box
s Steam Cock
t u Fire place
v w Brick Screen
x Connecting screw
1 2 Brass rod of scale
2 3 Scale
4 Vernier
5 Pinion of rack
6 7 Brass screen with interior thermometer
A B Pedestal of Column
C D Capital of the same





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The curve of the hot glass was so great that the workmen could scarcely prevent it from touching the pavement, (which of course would have caused its instant destruction,) by holding its extremities above their heads. While it was still red-hot and pliant, it was carefully laid upon the transverse pieces in the box, and rolled backwards and forwards till cool; by which a perfectly cylindrical form was secured. While the drawing process was going on, others of the workmen fanned with their hats, for the purpose of cooling, the parts which appeared to be extending too fast; and by such simple means a tube was perfected without a flaw, and of the greatest regularity; varying only from one inch diameter at its lower extremity to 0·8 inch at its upper.

The facility with which this process was conducted was so much greater than had been anticipated, that I immediately determined to have another tube made; that in case of any accident happening to the first, during the after operations, all the preliminary labour might not be thrown away. This was accordingly effected by rolling it upon the steps of a ladder placed horizontally upon the ground for that purpose. After it was cool it was lifted into the box by six men standing at equal intervals apart, and carefully placed by the side of the first. The box was then packed with hay, the cover screwed down, and carried upon men's shoulders to a convenient place for the further operations.

As it was not intended that the tubes should ever be removed from the case in which they had been originally deposited, the first step was to prepare the means of fixing them in their proper places when raised to the perpendicular position. For this purpose pieces of wood were provided of half the depth of the box, upon the upper edge of each of which a semicircle was hollowed out of the exact dimensions of half the cylinder of the tube. These were placed under the tube at equal intervals; and other similar pieces prepared for screwing down upon the upper side of the tube; in such a way that the two semicircles meeting, formed collars, which tightly embraced it, and fixed it in the centre of the box. The corners of the lower pieces were also cut away so as to inclose the spare tube (e,f), Plate XIX. which was placed in one of the angles of the case, and thus tightly fixed. The next object was to prepare the tube (a, b) itself for its final fixture; and for this purpose, as it was longer than was necessary, three feet were cut off from its upper extremity with a file; a small

thermometer (c, d) which had been made for the purpose, with a platinum scale carrying a spring of the same metal upon its back, was pushed down into the tube to a situation where it had been calculated it would always be immersed in the water, notwithstanding its oscillations; and where a slight tapering of the tube insured its being fixed by the action of the spring. By a careful application of the blow-pipe the glass was now softened, and an external collar (g) pushed up upon it, about eight inches from its upper extremity. This was deemed necessary to give it additional support, and to prevent its slipping in its proper position. The upper extremity was then contracted and drawn out into a small tube six inches long and of about one quarter of an inch diameter. These preparations having been successfully completed, a small stop-cock was fitted to the upper end of the contracted tube by very careful grinding, and secured in its place by a little white lead. The tubes were then again packed in their case, and the cover screwed down.

A small copper steam-boiler (h, i) was now constructed of what is called the waggon shape, and which was intended to form the cistern of the barometer. Without the cylindrical cover (k, l) it is eighteen inches long, eleven inches wide, and ten inches deep. Its bottom is slightly arched; and towards one extremity on the inside is fixed a small cylinder (m, n) six inches high and three inches diameter; the object of which is to form a receptacle into which, the lower end of the tube being made to dip, the great body of the water might at any time be drawn out of the cistern, if required, without, for a short time, disturbing the water in the tube, or allowing any air to ascend into the vacuum. A small hole (o) was afterwards drilled in this cylinder, which is six inches from the crown of the arch, and four inches and a half from the bottom; so that the water might be more completely withdrawn. At the other extremity is a cock (p) for drawing it off, if at any time it should be necessary to change it. The cover (k, l) is an arch of the height of six inches. Immediately over the cylinder above described, a length of five inches (k, q) is fixed and fitted with a stuffing-box for the glass tube to pass through. Beyond this it is made to take off, but may be fixed down by means of screws: on the summit of this moveable end a cock (s) is placed. The whole of the interior has been strongly tinned.

Everything being now prepared, the steam-boiler was set with brick-work

in a proper position over a small fire-place, with a temporary flue (*t*, *u*) at the foot of the well-staircase conducting to the apartments of the Society. With considerable difficulty and contrivance, the case with the glass tubes was introduced, by permission of the Antiquarian Society, through their library, and fixed against the stairs in a perpendicular direction, immediately over the stuffing-box; and the front of the box being removed, the tube was unpacked and suspended from above over the aperture. It was then very carefully lowered into its proper position in the boiler, and the wooden stays being screwed into their places, it was firmly adjusted. The stuffing-box (*m*, *n*), through which it passed into the boiler, was then packed with tow, and intended to be perfectly steam-tight. Part of the upper end of the deal-case was removed with a saw, so as to leave about six feet of the glass tubes exposed.

The object of the whole arrangement was as follows: first to boil the water in the cistern thoroughly, suffering the steam to escape by the cock (*s*), and then, by closing the latter, to raise the water in the tube, by the elastic force of the vapour acting upon its surface, till it issued in a jet from the small stop-cock upon its summit. When a sufficient current had thus been forced up, to secure the thorough wetting of the tube, and the total extrication of all particles of air, it was intended to close the stop-cock at the top while the water was still flowing, and at the same moment to relieve the pressure below by opening the cock upon the boiler, and again suffering the steam to escape. It was conceived that when the whole apparatus was cool, the column of water would subside, till it afforded a balance to the pressure of the atmosphere; when the small tube might be sealed by a dextrous application of the blow-pipe, and the stop-cock removed.

Everything being ready for the experiment, a preliminary trial was made of the apparatus on the 10th of June. The boiler was carefully washed with boiling distilled water, and the cover being screwed down, it was filled with distilled water to within five inches and a half of the top. The fire was then lighted in the grate, and in about two hours and a half a powerful current of pure steam issued from the cock (*s*). When this had continued for about half an hour, the cock was gradually closed, and the water rose very slowly in the tube. During its rise it oscillated backwards and forwards two or three

inches, but the column was perfectly unbroken and clear. On this occasion it was found impossible to raise it higher than thirteen feet, owing to the stuffing-box and cover not being sufficiently close. The cock upon the boiler was therefore gradually opened, and the column of water slowly subsided, the steam rushing out with considerable violence. Several practical points were determined by this experiment, which it was of importance to be acquainted with. The apparatus was found perfectly manageable; the pressure could be regulated with great precision by the cock, and the elasticity of the steam increased by very slow degrees, even when quite shut off. The temperature of the rising column was very moderate, and felt but just warm to the hand at the upper part.

Several little alterations were made in the fire-place, and the part (v, w) which was immediately under the tube was bricked up, so that the flame was cut off from the front of the boiler, that the steam might be raised from the back part only, and the possibility of any bubble passing up into the tube precluded. The stuffing-box was repacked, and the top screwed down with greater care. The water was drawn off, and fresh distilled water poured in.

It was now determined to prove the apparatus, by raising the column of water by condensed air; and for this purpose the pump of a soda-water machine was connected, by means of a flexible pipe and screw, with a collar (x) fixed for the purpose upon the arch of the boiler. As the condensation proceeded, the column of water rose steadily, till it issued with considerable force from the aperture of a small glass tube fixed into the stop-cock on the summit, and bent to an angle to prevent the waste water trickling down the apparatus. When the force of the jet began to decrease, the stop-cock was closed, and the cock on the boiler at the same moment opened. After a short interval the column of water began slowly to decline, and appeared to boil violently from the extrication of air from its surface. This effervescence continued for more than an hour, with decreasing force; and the formation of air bubbles could be perceived nearly half way down the column. After eighteen hours, the water stood in the tube at about thirty feet eight inches from the level of the water in the cistern.

Advantage was taken of this opportunity to ascertain the relative capacities of the tube and cistern; and it was found, by careful measurement, that the

fall of this quantity in the tube occasioned a rise in the level of that in the cistern of one inch and a half, affording a correction of very nearly 0·04 inch for ten inches. Everything having been thus prepared for the final experiment, a fire was lighted under the boiler at 11 A.M. of the 13th of June, and at half-past one pure steam issued with force from the cock (*s*) on the top of the boiler. When this was closed, the water began to rise slowly and steadily in the tube, oscillating at times about one inch and a half. More than an hour elapsed before the column of liquid reached the thermometer (*c*, *d*) at the upper end, when its temperature was found to vary from 85° to 90°. It still continued to rise very gently, till it issued with some force in an unbroken jet from the small tube which had been adjusted to the stop-cock. Three pints of water were thus drawn off, and the thermometer rose to 110°. The stop-cock on the top of the tube was then closed, and the cock on the top of the boiler simultaneously opened. The steam rushed forth from the latter with great violence, and after a considerable interval the column began very gently to fall from the top, without any boiling, or the slightest indication of air-bubbles. When it appeared to be stationary, the sealing was attempted; the small part of the tube, to which the stop-cock was attached, was successfully drawn off and closed without the slightest disturbance of the column of water; but in cooling it unfortunately cracked. The fissure thus occasioned was very minute, but rendered the resumption of the whole process necessary. The most difficult part of this to effect, was the drawing off and contraction of the tube to fit it again for sealing. It was determined, upon consideration, not to replace the stop-cock, but to rely upon the pressure of the operator's thumb to cut off the communication with the external air during the sealing.

As it was necessary to the operation that the tube should be turned upon its axis, it was unpacked from the stuffing-box of the boiler, and loosened from its different supports; and everything was again successfully adjusted with great dexterity by Mr. NEWMAN, who overcame the difficulties of these various processes with the greatest skill. It would be tedious to repeat the further steps of the progress; the boiling was conducted precisely in the manner which I have just described, and the tube was finally and permanently closed on the 18th of June. Not the slightest speck or air-bubble has from that moment been detected in the column of water.

While the water in the boiler, which now constitutes the cistern of the barometer, was still warm, a quantity of the purest castor oil (Oleum Ricini), was poured into it till the surface was covered to the depth of half an inch; this was done for the purpose of cutting off the communication of the atmosphere with the water, and with the view of preventing the absorption of the air. Some of the same oil was poured upon the surface of some distilled water in a wide-mouthed glass vessel, and being lightly covered with paper was set by in a closet, that any change might be detected to which it might be liable under such circumstances.

The adjustment of a scale was the next object of importance. For this purpose a hollow brass rod (1, 2) was prepared of $\frac{3}{8}$ths of an inch diameter, and adjusted by means of a screw at the upper end to a flat ruler of brass (2, 3) divided into inches, and carrying a vernier (4) by which the hundredth part of an inch is easily read off, and which is moveable from the outside of the case of the instrument by means of a rack and screw (5). The same rack and screw also moves a brass screen (6, 7), which rises and falls with the vernier and protects the tube from the heating influence of the breath or hand; a small thermometer is inserted into this screen. The rod was measured from a scale formerly belonging to the late Mr. Cavendish, and now the property of Mr. Newman, by marking it with a beam-compass at intervals of two feet, and afterwards repeating the process at intervals of sixteen inches. The two measures corresponded to the one twentieth of an inch; the difference being found to depend upon the multiplication of a small error in laying down the sixteen inches, and corrected accordingly.

The rod was next placed in the case of the barometer by the side of the tube, being made to pass through the wooden stays of the tube, in which it can freely move. At its lower end an ivory point of known length was fixed by which it was very carefully brought into exact contact with the surface of the oil in the cistern; the flat scale was then carefully adjusted to its upper end, and it was fixed at the lower end by screws to the top of the copper cistern. The column of water was thus found to stand exactly thirty-three feet four inches, or four hundred inches above the level of the fluid in the cistern. This, then, is the neutral point of the instrument, above or below which a correction of $\pm 0{\cdot}02$ inch must be made for every ascent or descent of five

inches in the tube. The whole instrument has been inclosed in an exterior ornamental case resembling an architectural column. The pedestal (A, B) conceals the boiler with its brick-work, and upon the capital (C, D) stands a glass-case including that part of the tube to which the oscillations are confined, and the apparatus for measuring them.

As much interest will attach to the accurate comparison of the water-barometer with the mercurial barometer, it is of great importance that several corrections should be attended to in the first reading of their respective heights, to reduce the columns to the same invariable circumstances under which alone such comparison can be properly made; for this purpose the variations of the density of the liquids, and the expansion of the scales, from variations of temperature, together with the capillary action of the tubes, must be taken into account. To facilitate this object, I have constructed the two following Tables of double entry; by which the observations may be reduced to the temperature of 40° (39°·38) or that of the maximum density of water, in which the expansion of the brass scales is also allowed for; which is a correction of considerable amount in the long scale of the water-barometer.

The data upon which these Tables have been calculated are as follows:

1st, The specific gravity of water at different temperature, as determined by the experiments of Hallström, taken from Dr. Thomson's late work upon Heat and Electricity, p. 28.

2nd, The determination of the linear expansion of brass at ·0000104 per degree of Fahrenheit.

The height of the column is assumed to be in inverse proportion to the specific gravity; and the correction to the maximum density at 40° (or more correctly 39°·38) is calculated accordingly. From this correction is deducted, or to it is added, the expansion or contraction of the brass scale on either side of 60°, calculated on the preceding datum.

Table of Corrections for Temperature for the Water-Barometer. Standard Temperature of Scale 60°. Maximum Density of Water 40°.

Temperature.		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Exact.	Approx.	350	360	370	380	390	400	410
35·6	35	—·101	—·103	—·106	—·108	—·112	—·115	—·118
39·38	40	—·072	—·074	—·077	—·079	—·081	—·083	—·085
44·6	45	—·073	—·075	—·077	—·079	—·081	—·083	—·085
50	50	—·113	—·115	—·118	—·122	—·124	—·128	—·132
55·4	55	—·191	—·195	—·201	—·206	—·211	—·217	—·223
59	60	—·258	—·264	—·272	—·279	—·286	—·294	—·302
64·4	65	—·398	—·409	—·420	—·431	—·443	—·454	—·466
69·5	70	—·575	—·590	—·606	—·623	—·639	—·656	—·673
75·2	75	—·786	—·808	—·831	—·853	—·876	—·898	—·921

With regard to the capillary action of the tube, which of course is in the opposite direction to that of the mercurial barometer, Dr. Young has calculated * that the central elevation for water in a tube of which the diameter is ·49964 inch (which is almost exactly the diameter of the tube within the range of the oscillations,) is ·035, and the marginal elevation ·172.

In my first use of the instrument I conceived that the observation was made with most certainty by bringing the vernier to coincide with the marginal elevation of the water; and in the following observations the correction of —·17 has been applied accordingly. Mr. Hudson has since shown me, that by reflecting the light upon the column from behind, the observation from the centre is made with the greatest precision; and in some observations which have been kindly furnished by that gentleman, the correction of —·03 only has been applied. The difference of the two corrections deduced from the calculation of Dr. Young as above, agrees very nearly with the difference of the two readings upon the barometer when carefully observed.

As the usual Tables for the thermometric correction of the mercurial barometer are calculated for 32°, I considered it necessary to calculate a fresh Table for the temperature of 40°; that both the water and the mercury might be reduced to the same standard temperature. The dilatation in volume of mercury per degree of Fahrenheit has been taken, on the authority of MM. Dulong and Petit, at ·0001001 of the volume at 32°. And the height of the

* Young's Lectures on Natural Philosophy, vol. ii. p. 669.

column has been assumed to be in the ratio of the volume at 40° to the volume at the observed temperature. To the correction thus obtained has been added, or from it has been deducted, the expansion or contraction of the brass scale on either side of the standard temperature 60°.

Table of Corrections for Temperature for the Mercurial Barometer. Standard Temperature of Scale 60°. Volume of Mercury at 40° Standard.

Temperature.	Inches. 28·	Inches. 28·5	Inches. 29·	Inches. 29·5	Inches. 30·	Inches. 30·5
35	+·007	+·008	+·008	+·008	+·008	+·008
40	—·005	—·006	—·006	—·006	—·006	—·006
45	—·018	—·018	—·018	—·018	—·019	—·019
50	—·030	—·031	—·032	—·032	—·033	—·033
55	—·043	—·043	—·044	—·045	—·046	—·046
60	—·056	—·057	—·058	—·059	—·060	—·061
65	—·069	—·070	—·071	—·072	—·074	—·075
70	—·081	—·082	—·084	—·085	—·087	—·088
75	—·094	—·096	—·097	—·099	—·101	—·102

The mercurial barometer, with which the following comparison has been made, is of a portable construction, and has been fully described on a former occasion*. It is the first to which a platinum guard was ever applied, and it still remains perfectly free from air. The correction of +·044 for capillary action has been experimentally verified, upon more than one occasion, by comparison with a barometer of half an inch bore, in which no such correction is necessary.

I have not hitherto had it in my power to institute such a series of observations as I think the interest of the subject would have justified; as I have been obliged to depend upon my own exertions, or of those who from pure love of science have been willing to assist me in this laborious drudgery, at such intervals as the pressure of other engagements would permit. Of these by far the most important are the hourly observations of Mr. Hudson, which, with the assistance of some members of his family, he had the resolution to persevere in for fifteen days, and which he has communicated to the Society. Prior to these, were the following observations made at my request by Mr. Roberton in the months of August and September 1830, at different hours of the day;

* Daniell's Meteorological Essays and Observations, 2nd edition.

but generally at 9 A.M. and 3 P.M. They include a very considerable range of temperature (from 57° to 74°), and serve to test the accuracy of the instruments brought into comparison shortly after the completion of the water-barometer, and that of the different corrections which have been applied to them.

The first column of the following Table records the date, and the second the hour of the observations. The third column contains the temperature of the internal thermometer (*c*, *d*), and the fourth that of the external thermometer (6, 7). The fifth shows the corrected height of the water-barometer; the sixth the temperature of the thermometer attached to the mercurial barometer. This, it will be observed, sometimes differs several degrees from the former; and, when this is the case, the mean has been taken as the temperature by which to correct the length of the scale; as standing at the bottom of the column, it most probably indicated the temperature of the lower extremity. The seventh column contains the corrected height of the mercurial barometer. In the eighth column I have placed the height of the column of water reduced to the corresponding height in mercury. As the basis of this calculation, I have taken the specific gravity of mercury at 40°, 13·624, as determined, at my request, by Mr. FARADAY at the time when I fitted up the large mercurial barometer belonging to the Society. The ninth column exhibits the differences of the two columns, or the amount of the depression of the column of water by the included vapour, expressed in parts of an inch of mercury.

By the side of these differences I have placed, in the tenth column, the elasticity of aqueous vapour due to the temperature of the surface water in the barometer, calculated from the data of Dr. URE. The eleventh column exhibits the differences of the two preceding. The mean results of every ten observations are also added to the register.

Register I.

Of the Temperature and Height of the Water and Mercurial Barometers.

1830.	Hour.	Thermometers. In.	Thermometers. Out.	Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	A.M.	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
July 31	3	74·5	74·6	396·605	73·8	29·979	29·110	·869	·877	+·008
Aug. 1	9	67·3	67·7	398·111	67·2	29·927	29·221	·706	·699	+·007
—	10	68·0	68·3	397·728	67·8	29·924	29·192	·732	·722	+·010
—	3	70·5	70·7	396·327	71·7	29·879	29·090	·780	·770	+·010
2	12	66·2	66·6	396·158	65·8	29·772	29·077	·695	·678	+·017
3	9	63·6	63·7	399·243	63·6	29·943	29·304	·649	·615	+·034
4	3	68·7	68·7	397·661	69·3	29·921	29·188	·733	·733	+·000
5	2	69·6	70·2	396·413	69·7	29·869	29·097	·772	·770	+·002
27	1	61·5	61·8	395·025	64·2	29·636	28·994	·642	·594	+·048
28	9	58·2	58·6	391·755	58·2	29·337	28·754	·583	·526	+·057
Means..	..	66·8	67·1	396·503	67·1	29·809	29·103	·706	·699	+·007
Aug. 28	12	58·8	58·2	391·732	59·4	29·350	28·753	·597	·543	+·054
—	3	59·6	60·0	392·294	60·4	29·396	28·794	·602	·560	+·042
29	9	57·8	59·2	398·837	59·0	29·854	29·274	·580	·526	+·054
—	3	59·8	60·5	399·333	60·8	29·913	29·310	·603	·560	+·043
30	9	57·8	58·6	403·059	57·6	30·157	29·584	·573	·526	+·047
—	1	59·4	60·2	402·396	60·8	30·150	29·535	·615	·560	+·055
—	3	60·6	61·2	401·993	60·6	30·135	29·506	·629	·568	+·061
31	9	57·8	58·8	403·959	57·4	30·228	29·650	·578	·526	+·052
—	3	60·6	61·8	402·696	61·0	30·206	29·557	·649	·577	+·072
Sept. 1	9	58·8	59·2	404·417	58·5	30·273				
Means..	..	58·9	59·7	400·071	59·5	29·966	29·364	·602	·543	+·059
Sept. 1	3	62·0	63·0	402·886	63·2	30·244	29·571	·673	·605	+·068
2	9	57·8	58·4	402·742	56·0	30·149	29·560	·589	·526	+·069
—	3	61·0	62·0	400·246	63·0	30·033	29·377	·656	·594	+·062
—	6	61·8	62·0	399·186	63·0	29·974	29·300	·674	·594	+·080
3	9	58·2	58·5	397·739	58·2	29·837	29·192	·645	·526	+·119
—	3	60·0	60·6	396·952	61·4	29·771	29·136	·635	·560	+·075
4	9	58·5	59·4	399·277	58·2	29·890	29·296	·594	·534	+·060
—	3	60·2	60·8	398·895	60·4	29·959	29·278	·681	·560	+·121
5	9	57·5	58·0	396·239	56·2	29·672	29·083	·589	·526	+·063
—	3	60·6	60·8	395·293	61·3	29·656	29·014	·642	·568	+·074
Means..	..	59·7	60·3	398·945	60·0	29·918	29·282	·636	·560	+·074
Sept. 6	9	58·2	58·8	394·135	58·8	29·532	28·916	·616	·534	+·082
—	3	59·2	59·8	392·911	60·0	29·457	28·781	·676	·551	+·125
7	9	58·8	59·2	396·356	59·2	29·682	29·092	·590	·543	+·047
—	3	59·5	59·8	396·614	59·6	29·700	29·111	·589	·551	+·038
8	9	58·1	58·6	400·057	58·2	29·949	29·364	·585	·526	+·059
—	3	60·8	61·3	399·675	60·3	29·962	29·335	·627	·577	+·050
9	9	57·0	57·6	398·328	56·0	29·819	29·236	·583	·508	+·083
—	3	58·2	58·2	397·177	57·8	29·762	29·152	·610	·526	+·084
Means..		58·7	59·1	396·906	58·7	29·732	29·132	·600	·543	+·057

The most striking result of this comparison is, the almost exact coincidence in the first ten observations of the elasticity of the aqueous vapour, derived from the experiment, with the amount as determined from calculation in a range of temperature from 58° to 74°; the differences in the eleventh column being much less than I should have anticipated, even from the necessary uncertainty in ascertaining the temperature by the thermometers.

The remaining series exhibit larger and rather increasing differences, but such only as might fairly be supposed to come within the limits of errors of observation. It must also be observed that they were taken at greater intervals apart, a circumstance which I shall presently show may have had a considerable influence upon the results. The differences in the last column are, however, all, except the first, marked with the positive sign +, denoting that the depression from observation is invariably greater than that which would have resulted from the calculated elasticity of the vapour. This would rather indicate some constant error in some of the data of the calculation than the necessarily fluctuating errors of observation; and we should only have to assume the specific gravity of mercury as 13·590 instead of 13·624, and the mean difference would disappear. There can, therefore, I think, be no hesitation in coming to the conclusion that, considering the difficulty and complexity of the several adjustments, and the variety of the necessary corrections applied to the observations, the whole arrangement was even more perfect than could have been expected, up to the time of this first register.

It was a principal object with me, as soon as possible to obtain a good and uninterrupted series of observations during a long period, taken at least once a day at some fixed hour; and for this purpose I engaged a careful workman of Mr. NEWMAN'S, who had been instructed in the reading of the different instruments, to keep a register of their indications at 7 A.M. in the summer months, and $7\frac{1}{2}$ A.M. in the winter. By a careful comparison of his readings with those of others, he was found to be fully competent to the task. The following register contains these observations for one year and a half, commencing in October 1830, and ending in March 1832. They have been corrected in the same way as the last, and the same kind of comparison instituted. The depression of the water-barometer has been worked out daily for the first two and the last months; but for the intermediate months I have satisfied myself with making the calculation for the monthly mean results.

The gradually increasing differences between this depression and the elasticity due to the vapour, have forced upon my mind the unwelcome conviction that, by some means or other, gaseous matter has crept into the instrument; and under this impression it was useless to carry the calculations further.

Register II.

Temperature and Height of the Water and Mercurial Barometers at 7 A.M. in the Summer, and $7^h\ 30^m$ A.M. in the Winter, from October 1830 to March 1832.

1830.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
October 9	56	56	406·48	55	30·416	29·836	·580	·492	·088
10	56	56	406·85	56	30·438	29·863	·575	·492	·083
11	55·5	55	405·63	50	30·369	29·773	·596	·484	·112
12	55·5	56	404·50	53	30·231	29·690	·541	·484	·057
13	55·5	55·5	405·04	52	30·329	29·730	·599	·484	·115
14	56	56	404·50	52	30·252	29·690	·562	·492	·070
15	55	54·5	403·46	50	30·215	29·614	·601	·476	·125
16	55	54	403·93	45	30·166	29·649	·517	·476	·041
17	54	54	405·08	47	30·322	29·733	·589	·460	·129
18	53·5	53	404·52	48	30·220	29·692	·528	·452	·076
19	55	55	400·50	54·5	29·905	29·397	·508	·476	·032
20	57	57	399·89	59	29·982	29·352	·630	·508	·122
21	58	59	401·38	59	30·124	29·461	·663	·526	·137
22	61	61	402·29	62	30·279	29·528	·751	·577	·174
23	61	60·5	403·56	58	30·310	29·621	·689	·577	·112
24	57	57	405·60	52·5	30·411	29·771	·640	·508	·132
25	55	55·5	401·34	55	30·080	29·458	·622	·476	·146
26	57	56·5	399·28	52	29·897	29·307	·590	·508	·082
27	50·5	50	405·97	41	30·348	29·798	·550	·407	·143
28	53	53	399·72	54	29·938	29·339	·599	·444	·155
29	56	55	394·85	55	29·655	28·982	·673	·492	·181
30	54·5	54	399·93	52·5	29·945	29·354	·591	·460	·131
31	54	53·5	399·32	54	29·901	29·310	·591	·460	·131
Means....	55·7	55·5	402·77	52·8	30·162	29·563	·599	·476	·123

1830.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
Nov. 1	56	56	401·18	57	30·066	29·446	·620	·492	·128
2	57	56·5	401·38	57	30·095	29·461	·634	·508	·126
3	56·5	56·5	398·75	57·5	30·009	29·268	·741	·500	·241
4	57	57	397·07	56	29·773	29·145	·628	·508	·120
5	56	55·5	399·11	56·5	29·897	29·294	·603	·492	·111
6	57	57	393·90	58	29·574	28·912	·662	·508	·154
7	57·5	57	388·51	58	29·093	28·516	·577	·517	·060
8	57	57	394·79	54·5	29·602	28·978	·624	·508	·116
9	55	54	398·74	52	29·855	29·266	·589	·468	·121
10	53	53	397·55	53	29·772	29·180	·592	·444	·148
11	55·5	55	394·61	55	29·498	28·964	·534	·476	·058
12	53	53	399·61	44·5	29·913	29·332	·581	·444	·137
13	51	51	399·24	52·5	29·863	29·304	·559	·414	·145
14	55	55	394·90	54·5	29·574	28·985	·589	·476	·113
15	54·5	54	394·60	54	29·492	28·964	·528	·460	·068
16	55·5	55	391·38	55	29·347	28·727	·620	·476	·144
17	55	55	392·66	54	29·420	28·821	·599	·476	·123
18	51	51	397·43	54	29·708	29·171	·537	·414	·123
19	52	52·5	402·97	50	30·156	29·578	·578	·428	·150
20	50·5	50	401·41	51	30·022	29·463	·559	·400	·159
21	50	49	400·01	52	29·904	29·367	·537	·394	·143
22	54	53	396·61	54	29·596	29·111	·485	·468	·017
23	53	53	402·18	52	30·115	29·520	·595	·444	·151
24	50·5	51	406·07	50	30·380	29·805	·575	·407	·168
25	47·5	47	406·68	47	30·368	29·850	·518	·364	·154
26	49	49	403·23	47·5	30·153	29·597	·556	·388	·168
27	48·5	49	398·00	49	29·760	29·213	·547	·388	·159
28	46·5	46	394·91	48·5	29·485	28·986	·499	·352	·147
29	49	48	398·15	50	29·741	29·223	·518	·382	·136
30	49	49	399·71	50	29·884	29·339	·545	·388	·157
Means....	53·1	52·8	398·18	52·8	29·770	29·226	·544	·444	·100

1830.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
Dec. 1	50·5	50	401·04	50	29·993				
2	48	48	399·52	49	29·857				
3	49	48	396·06	49	29·505				
4	47·5	47	397·97	48	29·717				
5	47·5	47	398·33	46	29·784				
6	47	47	389·76	49	29·121				
7	50	49	388·73	50	29·118				
8	55	55	390·13	50	29·175				
9	48	48	386·57	50	28·927				
10	51	51	387·49	50	28·992				
11	45·5	46	392·29	47	29·286				
12	43	43	393·99	47	29·374				
13	40	39·5	404·81	44	30·170				
14	43	43	407·13	46	30·394				
15	44	43	408·03	48	30·526				
16	43	43	406·57	48	30·334				
17	40·5	40	403·23	45	30·066				
18	40	40	404·37	43	30·172				
19	41·5	41	405·12	45	30·208				
20	43	43	395·23	47	29·475				
21	45	45	395·67	48·5	29·525				
22	47·5	47	396·11	50	29·576				
23	42	42	394·44	48	29·415				
24	34·5	36	392·90	41	29·455				
25	37	37	393·50	34	29·311				
26	36·5	36	393·95	40	29·347				
27	39	39	392·21	42	29·806				
28	40	40	389·81	44	29·048				
29	42	42	397·53	43	29·665				
30	42·5	43	395·13	45	29·488				
31	45	45	390.59	49	29·158				
Means....	44·1	44	396·39	46·3	29·613	29·094	·519	·328	·191

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
January 1	46	45	398·23	46	29·743				
2	46	46	399·31	50	29·823				
3	46	46	399·73	49	29·872				
4	47	47	399·29	46	29·862				
5	45	45	399·21	49	29·820				
6	47	47	403·73	47	30·170				
7	44·5	44	409·19	45	30·578				
8	41·5	41	409·79	44	30·604				
9	42	42	405·45	46	30·269				
10	45	45	400·12	48	29·882				
11	44	44	402·56	48	30·156				
12	45	44·5	402·64	47	30·078				
13	44	44	403·15	44	30·088				
14	44·5	44	403·63	48	30·157				
15	42·5	42	401·93	46	29·968				
16	41	41	399·75	45	29·832				
17	43·5	43	396·63	46	29·518				
18	45	45	395·43	46	29·548				
19	48	48	396·30	50	29·617				
20	46·5	46	393·65	50	29·425				
21	48	48	389·21	47	29·117				
22	50	50	389·94	52	29·187				
23	50	50	390·93	53	29·274				
24	46·5	46	394·44	49	29·455				
25	45·5	45	398·27	47	29·756				
26	39·5	39	403·22	44	30·069				
27	43	43	401·89	41	30·049				
28	43·5	43	396·85	46	29·530				
29	42	42	400·17	45	29·863				
30	41·5	41	399·75	45	29·830				
31	42	42	398·53	45	29·753				
Means....	44·7	44·5	399·45	46·9	29·835	29·319	·516	·340	·176

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
February 1	42	41·5	390·61	44	29·177				
2	42	42	390·08	44	29·188				
3	41	41	394·31	44	29·431				
4	45·5	45	388·04	48	29·031				
5	43	43	396·29	47	29·580				
6	43·5	43	400·59	46	29·931				
7	45·5	45	394·46	48	29·490				
8	49	49	398·68	52	29·849				
9	51·5	51	399·35	53	29·723				
10	53	53	402·21	54	30·169				
11	55	55	402·07	55	30·196				
12	53	53	402·82	56	30·230				
13	53·5	53	402·47	56	30·212				
14	54	54	402·17	53	30·169				
15	53	53·5	401·18	50	30·056				
16	52	52	397·86	51	29·825				
17	50·5	50	398·95	52	29·876				
18	48	47	403·08	51	30·172				
19	48	48	401·28	51	30·050				
20	48	47·5	399·87	47	29·935				
21	45	44·5	401·63	43	30·045				
22	43	43	401·17	47	29·995				
23	44·5	44	406·16	42·5	30·389				
24	45·5	45	403·14	47	30·158				
25	49	48	397·98	50	29·820				
26	47	47·5	391·20	50	29·209				
27	46·5	46	391·74	49	29·325				
28	46	46	394·59	46	29·526				
Means....	47·8	47·5	398·35	49·2	29·813	29·239	·574	·376	·198

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
March 1	44	43·5	398·94	48	29·810				
2	46·5	46	397·56	50	29·763				
3	51·5	51	394·41	53	29·582				
4	53	52·5	395·64	54	29·676				
5	52·5	52	397·23	55	29·818				
6	53	53	389·37	55	29·167				
7	52	51·5	384·48	54	29·581				
8	49	48·5	397·12	53	29·773				
9	50	50	394·19	53	29·528				
10	48	48	398·83	50	29·871				
11	53·5	53	396·05	54	29·724				
12	49·5	49	398·94	53	29·907				
13	50·5	50	394·99	52	29·632				
14	50	49·5	395·42	52	29·644				
15	48·5	48	397·20	51	29·767				
16	52	52	394·50	53	29·566				
17	54·5	54	396·88	56	29·816				
18	54·5	54	401·01	55	30·130				
19	49	49	402·48	51	30·194				
20	50	50·5	400·92	45	30·037				
21	52·5	52	400·18	53	30·044				
22	51·5	51·5	402·42	47	30·199				
23	48	48	404·55	49	30·347				
24	44·5	44	401·02	47	30·031				
25	44	44	396·11	47	29·656				
26	46	46	391·73	48	29·342				
27	49·5	49	397·82	51	29·838				
28	51	51	399·74	48	29·994				
29	50	50·5	401·41	45	30·127				
30	48	48	403·08	43	30·232				
31	47	47	404·82	48	30·352				
Means....	49·8	49·5	397·71	50·8	29·843	29·191	·652	·400	·252

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
April 1	47·5	47	404·81	50	30·422				
2	45·5	45	401·11	49	30·045				
3	46	46	399·65	49	29·944				
4	46·5	46	396·43	50	29·604				
5	45·5	45	393·76	49	29·484				
6	49	49	392·98	50	29·462				
7	49	49	391·51	47	29·382				
8	52	52	388·58	54	29·220				
9	51	51	393·19	54	29·434				
10	53	53	393·14	55	29·530				
11	54	54	397·99	55	29·909				
12	54	54	397·36	53	29·883				
13	56	56	390·32	53	29·883				
14	57	57	389·75	54	29·873				
15	54·5	54	398·48	55	29·971				
16	56	56	390·50	54	30·003				
17	56	56	389·81	53	29·933				
18	52	52	399·43	53	30·016				
19	52·5	52	398·12	48	29·924				
20	52	52	396·51	51	29·697				
21	53	53	392·91	49	29·544				
22	54	54	390·97	52	29·407				
23	56	56	391·69	52	29·470				
24	55·5	55	395·42	53	29·762				
25	55	55	397·95	53	29·943				
26	55	55	395·82	52	29·795				
27	56	56	393·48	53	29·620				
28	55·5	55	390·49	52	29·324				
29	55	55	397·83	51	29·185				
30	56	56	390·84	56	29·397				
Means....	52·7	52·5	394·69	51·9	29·702	28·970	·732	·432	·300

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
May 1	55	55	390·86	54	29·400				
2	56	56	391·74	52	29·479				
3	55·5	55	393·00	53	29·568				
4	56	56	389·84	57	29·587				
5	54	54	392·22	48	29·484				
6	51	51	395·38	52	29·685				
7	48·5	49	399·25	51	29·974				
8	48·5	49	402·21	52	30·203				
9	50	50	433·55	52	30·285				
10	52	52	401·01	54	30·163				
11	51	51	400·00	53	30·136				
12	54	54	399·95	55	30·100				
13	55	55	397·28	52	29·919				
14	54	54	399·01	48	30·026				
15	51·5	52	398·93	47	30·001				
16	54	54	399·43	50	30·064				
17	56	56	400·05	55	30·153				
18	58	58	397·53	57	29·994				
19	58·5	58	394·23	57	29·753				
20	61	61	393·49	61	29·639				
21	60·5	60	394·90	59	29·827				
22	59·5	60	396·66	58	29·950				
23	59	59	395·19	57	29·846				
24	61	61	393·88	60	29·785				
25	62	62	393·77	61	29·771				
26	61	61	394·35	58	29·802				
27	59	59	393·66	55	29·736				
28	58·5	59	395·44	57	29·841				
29	58	58·5	396·31	56	29·913				
30	57	57	395·69	55	29·838				
31	57	57	396·99	55	29·930				
Means....	55·9	55·9	397·28	54·5	29·866	29·161	·705	·492	·213

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
June 1	57	57	395·59	57	29·843				
2	58	58	398·21	55	30·063				
3	58	58	398·54	55	30·100				
4	59	59	390·52	56	30·130				
5	60	60	397·47	59	30·058				
6	59	59	390·01	56	29·900				
7	58	58	390·30	55	30·010				
8	57	57	394·58	55	29·787				
9	58	57·5	394·47	56	29·795				
10	60	60	392·25	59	29·642				
11	60	60	390·64	60	29·539				
12	62	62	392·31	62	29·709				
13	62	62	393·72	61	29·791				
14	62·5	62	397·07	61	30·076				
15	62	62	394·76	62	29·827				
16	61	61	393·50	60	29·775				
17	61	61	394·48	59	29·864				
18	61	61·5	395·65	60	29·946				
19	63	63	394·08	63	29·848				
20	61·5	61	397·53	59	30·101				
21	62	62	397·63	60	30·129				
22	63	62·5	397·32	61	30·128				
23	64	64	397·11	66	30·129				
24	63·5	63	394·51	59	29·915				
25	61·5	61·5	392·59	60	29·718				
26	59·5	60	390·85	58	29·568				
27	59	59	394·60	57	29·837				
28	60	60	393·94	59	29·814				
29	59·5	59·5	395·83	58	29·954				
30	59·5	59·5	395·49	58	29·926				
Means....	60·4	60·3	394·52	58·9	29·897	28·952	·945	·560	·385

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
July 1	60	60	396·67	59	30·030				
2	61	61	395·55	59	29·959				
3	62	62	394·97	61	29·935				
4	62·5	62·5	397·17	61	30·126				
5	64	64	397·06	63	30·165				
6	65	64·5	398·21	64	30·259				
7	64·5	64·5	398·23	63	30·269				
8	64	64	397·16	62	30·167				
9	65	64·5	396·03	63	30·093				
10	68	68	393·38	67	29·977				
11	63·5	63·5	392·76	62	29·832				
12	65	65	389·30	64	29·586				
13	64	64·5	389·02	63·5	29·627				
14	63	62·5	390·74	63	29·668				
15	62	62·5	391·02	62	29·679				
16	62·5	62·5	391·23	63	29·697				
17	62	62·5	393·50	63	29·878				
18	62·5	62	394·58	62·5	29·956				
19	62·5	62	393·18	62·5	29·860				
20	63	62·5	391·65	62·5	29·750				
21	64·5	64	389·78	65	29·626				
22	62	61·5	392·13	63	29·756				
23	62·5	62	392·10	63	29·768				
24	61·5	61·5	391·80	60	29·730				
25	63	62·5	394·73	61	29·985				
26	63	62·5	396·11	61·5	30·097				
27	65	64·5	396·30	63	30·166				
28	67·5	67	394·68	66	30·097				
29	67·5	67	394·02	66	30·034				
30									
31									
Means....	63·5	63·3	393·90	62·7	29·923	28·912	1·011	·636	·475

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
August 1	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
2	67	67	391·40	66·5	29·831				
3	67·5	68	390·84	67	29·818				
4	67	67	390·32	66	29·756				
5	68·5	69	398·14	68	29·603				
6	67	66·5	399·34	64	29·655				
7	66	66·5	398·75	66	29·603				
8	66	66	390·45	64	29·739				
9	68	68	391·54	67	29·870				
10	68	68	392·50	65·5	29·950				
11	67	67	394·74	64·5	30·072				
12	66	66	394·64	63	30·083				
13	66·5	67	393·30	64·5	30·003				
14	66	66	392·89	63	29·946				
15	65·5	65	393·95	62	30·026				
16	66	66	394·10	63	30·061				
17	65	65·5	393·46	64	29·992				
18	64·5	64	392·67	60	29·895				
19	62	62	389·78	61	29·646				
20	62	62	388·25	60·5	29·516				
21	63·5	64	393·94	63·5	29·986				
22	63	62·5	396·87	61	30·266				
23	64·5	64·5	395·26	63·5	30·125				
24	65·5	65	392·66	63	29·925				
25	64·5	64·5	389·00	63	29·618				
26	62	62	393·03	59·5	29·885				
27	63·5	64	392·45	64	29·889				
28	65	64·5	393·91	60·5	30·004				
29	63	62·5	395·89	59·5	30·141				
30	64·5	64·5	394·55	62	29·876				
31	66	66	391·42	66	29·880				
Means....	65·3	65·3	393·33	62·0	29·889	28·870	1·019	·657	·462

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
Sept. 1	63	62·5	392·65	60	29·887				
2	59	59	392·13	54	29·767				
3	58	58	393·51	53	29·852				
4	58	58	392·56	54	29·786				
5	62	62	392·11	63	29·721				
6	64	63·5	391·94	64	29·846				
7	61	60·5	392·48	56	29·835				
8	58·5	58	390·97	54	29·656				
9	57	57	389·34	53	29·541				
10	57·5	58	392·14	66·5	29·720				
11	57	57·5	394·18	56	29·908				
12	58·5	59	396·36	59	30·101				
13	59	59·5	396·79	57·5	30·159				
14	59·5	60	395·80	59	30·071				
15	59	59	396·24	56	30·100				
16	59	59	396·76	59	30·150				
17	59	59·5	397·09	58	30·190				
18	59	59	395·54	58	30·069				
19	59·5	59	397·32	58	29·884				
20	57·5	58	392·70	52	29·798				
21	58·5	59	391·64	59	29·745				
22	59	59	393·04	56·5	29·857				
23	58	57·5	395·68	55	30·029				
24	59·5	59·5	396·70	59·5	30·152				
25	60	60	394·59	59	30·001				
26	61	61	393·83	61	29·958				
27	61	61	392·83	60	29·855				
28	62	61·5	390·77	60	29·680				
29	62·5	62·5	388·51	62	29·577				
30	63	63	387·34	62·5	29·502				
Means....	59·6	59·7	393·45	58·1	29·880	28·879	1·001	·560	·441

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
October 1	63·5	63·5	384·11	63·5	29·236				
2	63	62·5	384·94	62	29·269				
3	62	62	389·45	60	29·610				
4	62	62	390·52	61	29·689				
5	61·5	61	392·07	59	29·805				
6	59·5	59·5	393·23	59	29·874				
7	62	61·5	390·60	63	29·711				
8	63	62·5	389·55	61·5	29·658				
9	61	60·5	389·73	57	29·613				
10	59·5	60	399·31	59	29·558				
11	61	61·5	389·92	61	29·629				
12	60	60·5	390·61	61	29·694				
13	60·5	60·5	390·00	60	29·641				
14	63	62·5	388·20	64	29·538				
15	62	62	390·61	63	29·605				
16	60	60·5	395·63	60	30·091				
17	58·5	58	398·59	54·5	30·288				
18	60	60	398·98	59	30·354				
19	60·5	60	397·06	59	30·213				
20	61	60·5	393·84	59	29·937				
21	60	60	392·94	58	29·866				
22	57	57	395·53	52	30·007				
23	59	59	393·77	60	29·918				
24	59	59	395·23	57·5	30·031				
25	57·5	58	393·34	56·5	29·878				
26	59	59	388·33	59·5	29·477				
27	58·5	59	390·75	58·5	29·672				
28	58	58	394·47	57	29·946				
29	57·5	58	398·09	57·5	30·260				
30	56·5	56·5	398·53	52·5	30·265				
31	56·5	56·5	397·22	56	30·165				
Means....	60	60	392·75	59	29·824	28·827	·997	·560	·437

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
Nov. 1	57	57	395·11	57	30·002				
2	57	57	391·77	58	29·722				
3	51·5	51	389·52	54	29·473				
4	49·5	49	392·97	50	29·696				
5	51	50·5	390·70	51·5	29·557				
6	51·5	51·5	391·43	51	29·616				
7	53	52·5	388·99	52	29·431				
8	51·5	51	391·36	52·5	29·601				
9	52	51·5	397·31	50·5	30·086				
10	51	51	401·12	45	30·416				
11	50	50	398·83	52	30·212				
12	53·5	53	399·17	54	30·278				
13	52·5	52·5	395·39	50·5	29·963				
14	50	50	392·11	48	30·064				
15	50	49·5	390·05	49·5	29·476				
16	44	44	388·37	46·5	29·283				
17	43	43	392·17	45	29·539				
18	42	42·5	393·49	43	29·669				
19	43	43	390·26	45	29·420				
20	42·5	42·5	394·93	45	29·761				
21	48	48	392·17	48·5	29·621				
22	51·5	51	393·77	52·5	29·807				
23	54	53·5	394·86	55	29·932				
24	54·5	55	395·30	55	29·973				
25	55	55	394·51	56	29·931				
26	56	56	393·74	56·5	29·888				
27	54	54	398·74	53	30·245				
28	48·5	48	402·41	48	30·468				
29	46·5	46	403·07	50	30·522				
30	46	45·5	400·95	45·5	30·343				
Means....	50·3	50·1	394·49	50·7	29·866	28·955	·911	·400	·511

1831.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
Dec. 1	48	48	398·17	50·5	30·135				
2	50·5	50	396·35	52	30·021				
3	52	51·5	397·29	52·5	30·120				
4	51	50·5	396·25	51·5	30·013				
5	51·5	51·5	393·73	52·5	29·814				
6	52	52	388·33	53	29·385				
7	53	53	382·21	54·5	28·962				
8	54	54	384·41	55·5	29·124				
9	56	56	384·33	57·5	29·139				
10	55·5	55	387·54	57	29·366				
11	56	56	386·65	57·5	29·315				
12	56·5	56	386·64	56	29·308				
13	56·5	56	386·66	57	29·306				
14	56	56	389·44	55·5	29·539				
15	55	55	382·29	51	29·740				
16	54	54	383·35	50	29·820				
17	52·5	52	391·95	52	29·674				
18	53	53	387·43	54	29·330				
19	51	50·5	390·15	50	29·507				
20	51	51	393·05	53·5	29·760				
21	52	52	391·01	53	29·623				
22	49·5	49	394·33	48	29·853				
23	49	49	393·42	48	29·765				
24	47	46·5	399·04	50	30·196				
25	44	43·5	400·99	41	30·346				
26	43	43	400·30	46	30·261				
27	44	44	401·82	4	30·435				
28	44·5	44	401·85	46	30·416				
29	46	45·5	400·46	47	30·320				
30	46·5	46	399·15	46	30·210				
31	45·5	45	399·43	44·5	30·221				
Mean....	50·5	50·6	392·51	51·2	29·775	28·786	·989	·414	·575

1832.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
January 1	44	44	399·60	41	30·236				
2	44·5	44	399·61	43	29·977				
3	43	43	394·88	45	29·822				
4	44	43·5	393·58	43	29·531				
5	42·5	42	392·88	41	29·661				
6	43·5	43	391·45	46	29·558				
7	45	45	389·03	46·5	29·404				
8	45·5	45	389·14	49	29·383				
9	46	46	390·37	49	29·484				
10	48·5	48	391·17	50	29·566				
11	50	50	393·33	53	29·781				
12	50	49·5	393·63	52	29·801				
13	50	50	393·62	49	29·574				
14	48	48	397·77	45	30·119				
15	46·5	46	401·79	44	30·436				
16	45	45	402·23	47	30·467				
17	47	47	400·43	47	30·333				
18	48·5	48	400·21	51	30·337				
19	48	48	400·42	48	30·332				
20	45	45	398·77	41	30·173				
21	46·5	46	398·64	46·5	30·178				
22	48	48	399·08	49	30·235				
23	48·5	48	399·65	47	30·284				
24	47	47	399·18	49	30·225				
25	49	49	393·79	50	29·808				
26	48	48	394·18	48·5	29·844				
27	49	48·5	395·10	46	29·905				
28	45·5	45	399·47	43	30·235				
29	47	47	398·53	48	30·184				
30	48	48	399·93	48	30·317				
31	49·5	49	397·03	50	30·146				
Means....	46·8	46·6	396·38	47	29·979	29·094	·885	·364	·521

1832.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
February 1	48	48	390·22	47	29·523				
2	50·5	50	386·22	51	29·218				
3	50	49·5	389·46	46	29·459				
4	50·5	50	393·41	51	29·797				
5	52	52	395·35	53·5	29·983				
6	53·5	53	393·10	54·5	29·816				
7	52	52	394·16	50	29·888				
8	49·5	49	399·63	52	30·301				
9	51	51	400·04	52	30·364				
10	50	49·5	402·41	50	30·542				
11	50	49·5	400·21	49	30·350				
12	48	47·5	397·94	51·5	30·154				
13	48	47·5	397·18	49	30·073				
14	47	47	396·80	50·5	30·054				
15	46	44·5	397·37	48	30·060				
16	43	42·5	395·17	41·5	29·867				
17	45	45	393·02	48	29·708				
18	46	46	398·35	49	30·165				
19	47	46·5	400·02	50	30·307				
20	46	46·5	400·11	46	30·325				
21	46	45·5	399·43	48	30·263				
22	44	44·5	400·42	49	30·324				
23	44	44	400·05	43	30·380				
24	43	43	398·89	46	30·168				
25	42	42	397·21	43	30·019				
26	43	42·5	399·22	43·5	30·213				
27	46	46	397·72	44	30·112				
28	44·5	44	398·80	48	30·104				
29	44	44	398·91	48	30·193				
Means....	47·2	47	396·92	48·3	30·060	29·133	·927	·364	·563

1832.	Thermometers.		Water-Barometer.	Temperature of Mercury.	Mercurial Barometer.	Water-Barometer reduced to Mercury.	Difference.	Elasticity of Vapour.	Difference.
	In.	Out.							
	°	°	Inches.	°	Inches.	Inches.	Inch.	Inch.	Inch.
March 1	44	44·5	399·85	46	30·280	29·349	·931	·328	+·603
2	47	47	399·83	49	30·299	29·348	·951	·364	+·587
3	46	46·5	399·82	47	30·305	29·346	·959	·352	+·607
4	48	47·5	396·26	48	30·018	29·085	·933	·376	+·557
5	48·5	48	393·23	49·5	29·770	28·864	·906	·376	+·530
6	47	46·5	394·16	49	29·829	28·916	·913	·364	+·549
7	48	48	388·58	49	29·391	28·521	·870	·376	+·494
8	45	45	390·14	45	29·486	28·636	·850	·340	+·510
9	44·5	44	396·73	45	30·008	29·120	·888	·328	+·560
10	45	45	401·05	48	30·377	29·437	·940	·340	+·600
11	44	44	398·98	43·5	30·205	29·285	·920	·328	+·592
12	44	44·5	397·03	48	30·042	29·142	·900	·328	+·572
13	45	45	394·79	48	29·920	28·978	·942	·340	+·602
14	47	46·5	390·16	49	29·507	28·637	·870	·364	+·506
15	46·5	46	388·45	49·5	29·360	28·512	·848	·352	+·496
16	47·5	47	393·83	43	29·816	28·907	·909	·364	+·545
17	50	49·5	388·53	50·5	29·415	28·518	·897	·400	+·497
18	49	48·5	389·91	49	29·503	28·619	·884	·388	+·496
19	48	48	394·17	47·5	29·847	28·932	·915	·376	+·539
20	50	50	389·41	50	29·492	28·583	·909	·400	+·509
21	50	50	395·59	51·5	29·995	29·036	·959	·400	+·559
22	51	50·5	397·12	52·5	30·128	29·148	·980	·414	+·566
23	52	52	394·76	54	29·961	28·975	·986	·428	+·558
24	52	51·5	393·15	47·5	29·818	28·857	·961	·428	+·533
25	47·5	47·5	397·31	50·5	30·117	29·162	·955	·364	+·591
26	48	48	397·86	51	30·164	29·203	.961	·376	+·585
27	50	50	395·87	47·5	30·010	29·057	·953	·400	+·553
28	48	48·5	396·94	52	30·090	29·135	·955	·376	+·579
29	49	49	395·68	47·5	29·989	29·042	·947	·388	+·559
30	49·5	49	394·89	51·5	29·972	28·985	·987	·388	+·599
31	50	50	393·31	52	29·824	28·869	·955	·400	+·555
Means....	47·8	47·6	394·75	48·7	29·901	28·974	·927	·376	+·551

It will be observed how very gradually the differences, recorded in the last columns of the months, increase; till, in the month of March 1832, they average ·551; more than half an inch of mercury, indicating a mean depression of the water-barometer of more than seven inches. This result is further confirmed by a comparison of the monthly mean heights of the two instruments, and by observing that in the month of March 1832, when the differences for each day are exhibited, the greatest differences occur with the highest barometer, as would happen from the greater compression of included air under such circumstances. The regularity of this secondary effect is indeed very remarkable.

This unfortunate result not being doubtful, I determined to open the boiler for the purpose of throwing some light, if possible, upon the cause. Dr. Prout, to whose valuable advice I have been greatly indebted in all the previous arrangements, did me the favour of assisting at this examination.

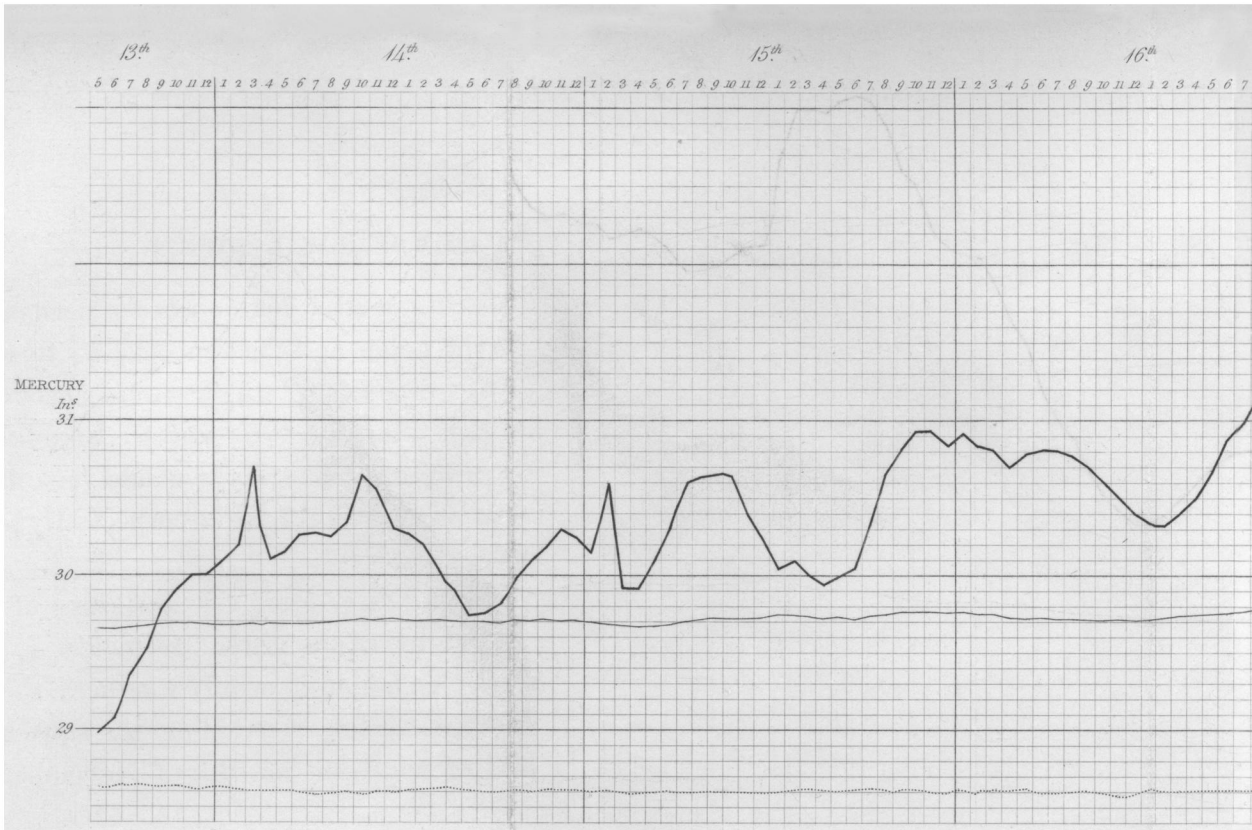
Upon removing the cover, we found that a portion of the liquid had by some means escaped, as, although the column of water stood considerably below the neutral point, the ivory point was not in contact with it. We carefully measured its distance, and found it to be 0·3 inch, to which, as the barometer stood at 385·94 inches, must be added 0·05 inch for the difference from the neutral point; and the amount 0·35 inch will be the quantity of the fluid deficient.

Upon examining the oil upon the surface, we found that it had undergone a very remarkable change. It was nearly covered with large clots of a mucilaginous-looking substance, which, in places, reached quite through to the water beneath; so that upon moving them aside the latter was uncovered. Upon the top of this, in various parts, were drops of an aqueous fluid, of a tenacious consistence, which had a very decided sweet taste, and resembled the substance which is formed during the process of saponification, to which the name of Glycerine has been given. There was also some carbonaceous matter, but not more than might probably be accounted for from depositions from the atmosphere. All these matters, with a great portion of the remaining oil, were carefully skimmed off, and the water beneath was found perfectly bright and transparent; there were no signs of metallic corrosion in any part, and every portion of the boiler, with its cover and brass-work, was as bright as on the day when they were put together.

We next examined the portion of oil and water which had been set by in a glass vessel for the purpose of watching any changes which it might undergo. This we found in a very different state. The stratum of oil upon the surface was rather more than an inch thick, and in this it differed from that in the boiler, which was not more than half an inch. The great body of it was perfectly bright and pure, and did not seem, from its taste, to have undergone any change, or to have acquired any rancidity. At the point of contact with the water it appeared to have undergone change, and to be separated from it by a tough film of the same mucilaginous-looking substance which we had found in the boiler. Upon agitating the glass, this film could be bent upwards without breaking; and a kind of fold was made in it of so tenacious a quality as to be some time before it again accommodated itself to the level of the liquid. Upon examination with a lens, it appeared to contain minute air-bubbles. These air-bubbles may have originated from some decomposition of the oil or water; but they were by no means numerous, and it is not at all improbable that they were the remains of a thin stratum of air included between the oil and the water; as there would be no perfect contact between the two liquids near the surface of the water. We next placed the glass, with its contents, under the receiver of an air-pump, and upon exhaustion of the air these little bubbles expanded and seemed to lift the film in parts and to escape with some difficulty through the oil. No air-bubbles, however, were formed in the mass of the subjacent water; proving that the water had been, in this instance, protected by the oil. Upon pushing the exhaustion to the utmost, a few insignificant bubbles were indeed extricated from a small flock of dust which had fallen to the bottom of the glass.

A little of the water was then taken out of the boiler in a glass vessel, which still retained a thin stratum of oil upon its surface. Upon exposing this to the action of the pump, air-bubbles in abundance were extricated from the whole mass, and it swelled up so as nearly to overflow the vessel in which it was contained; presenting a very marked contrast to the result of the previous experiment, and proving that the water in the boiler must have been strongly impregnated with gaseous matter. This examination took place on the 13th June, almost exactly two years from the completion of the water-barometer.

Upon consideration of all the circumstances, we were of opinion that the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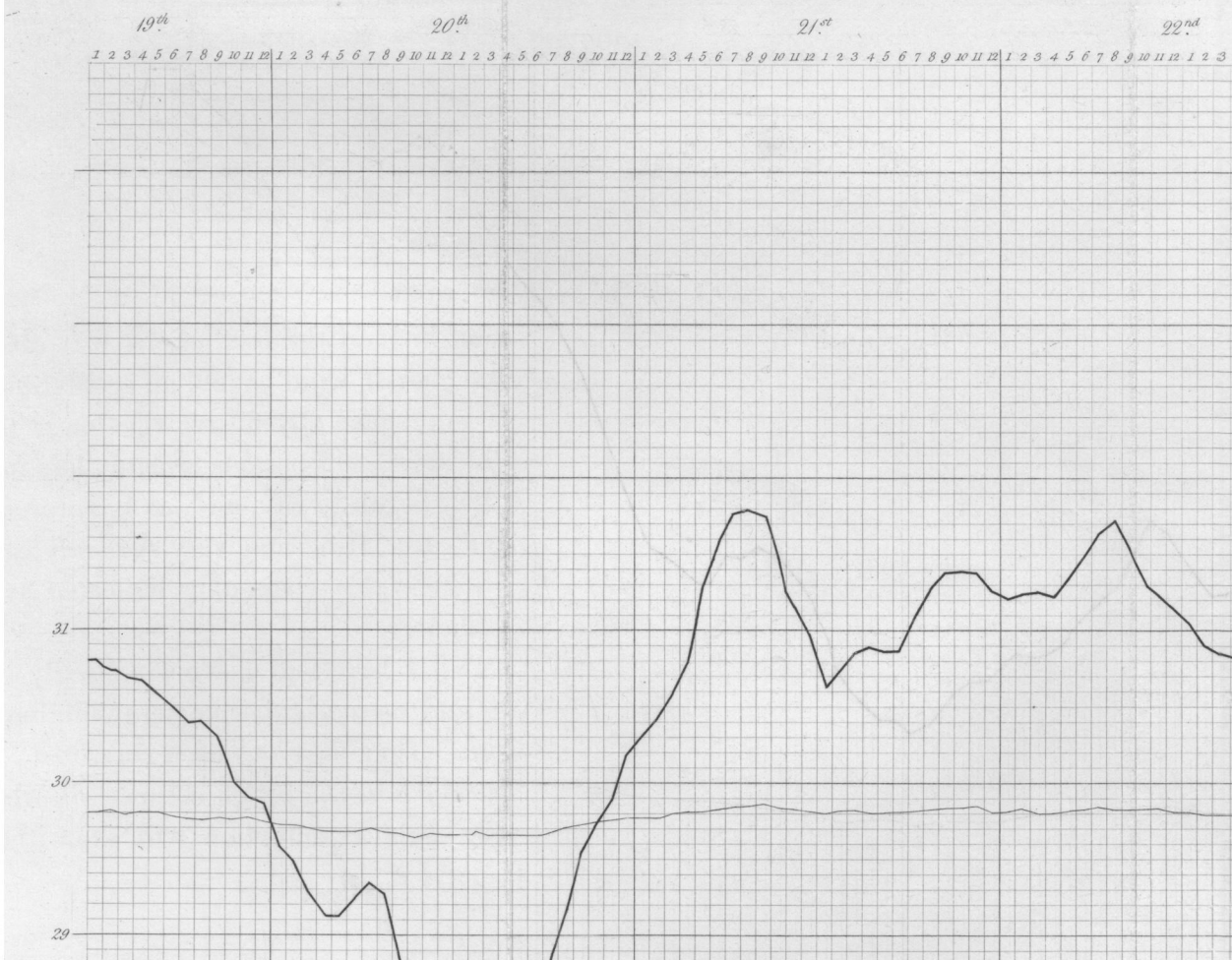
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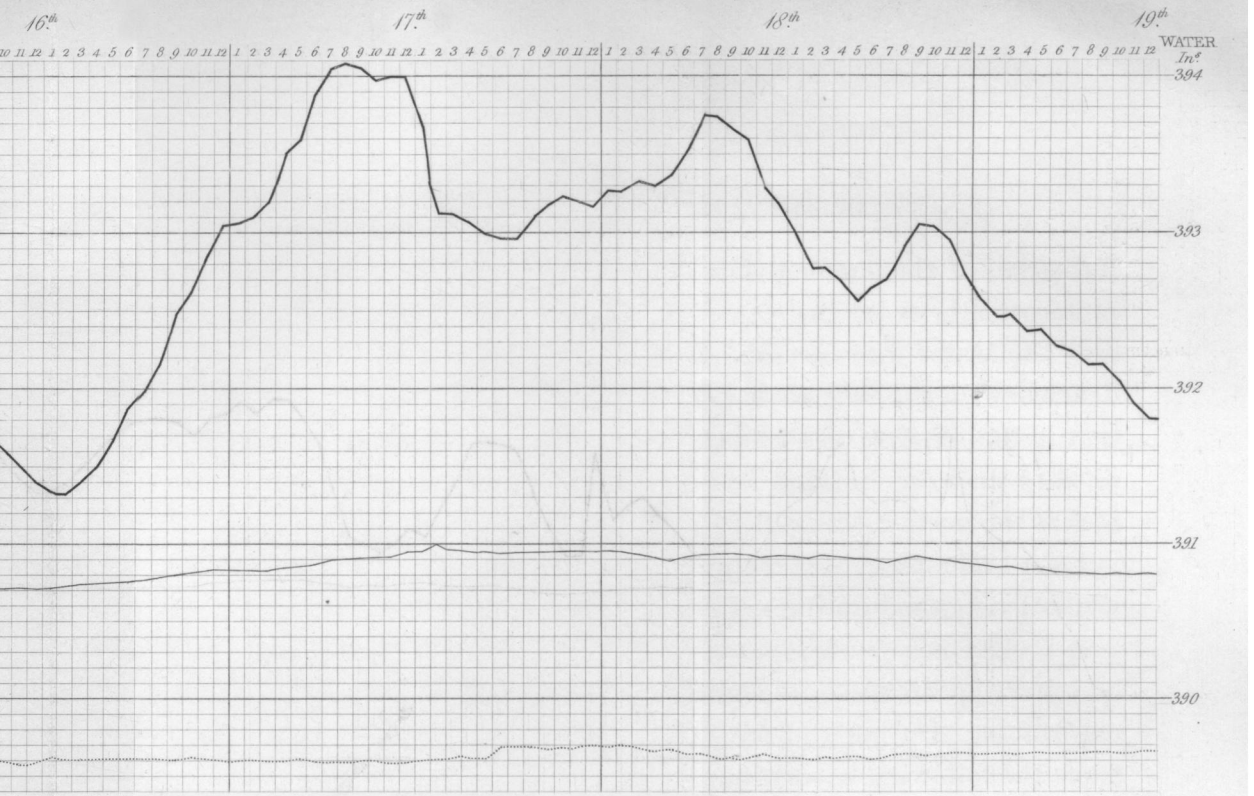
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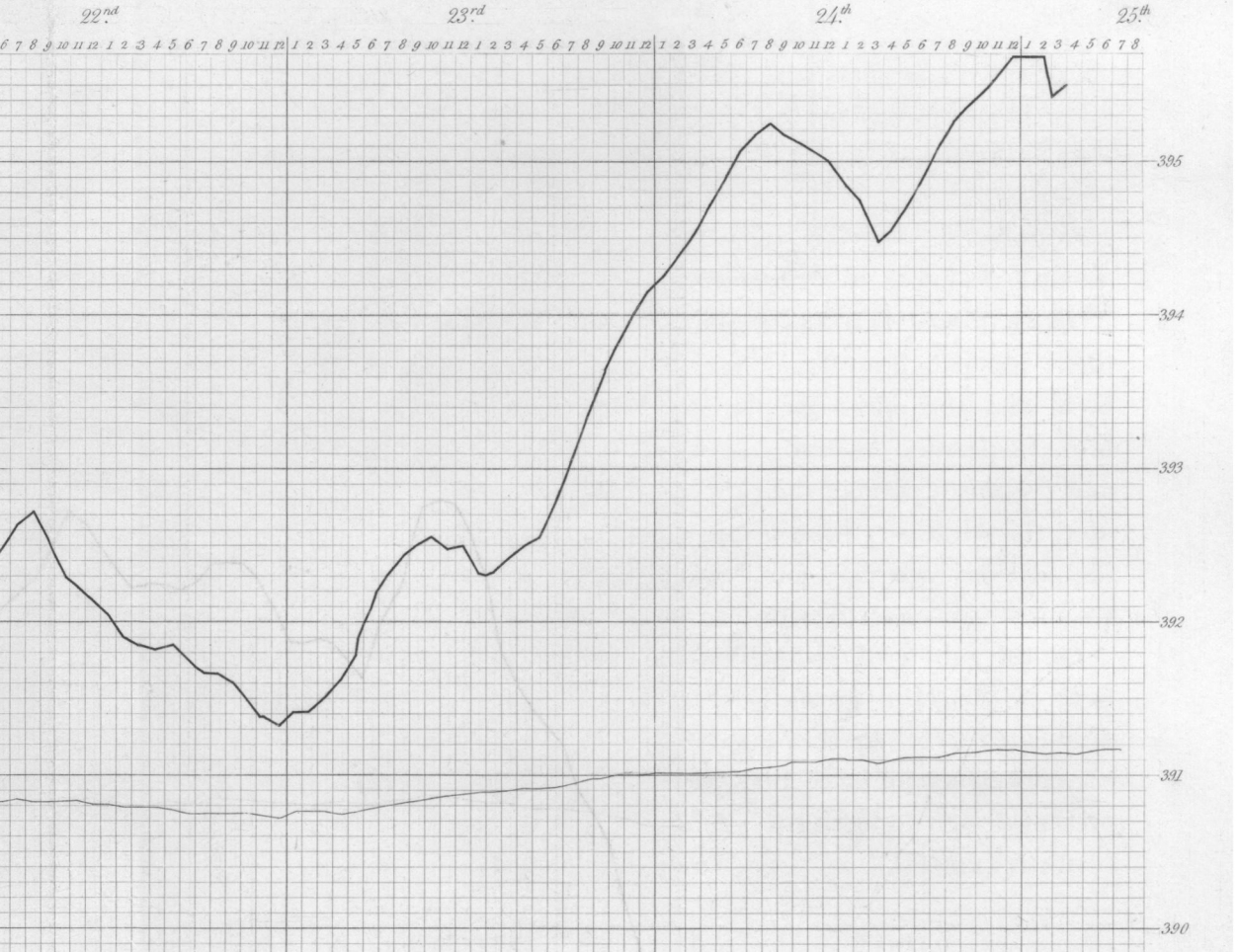
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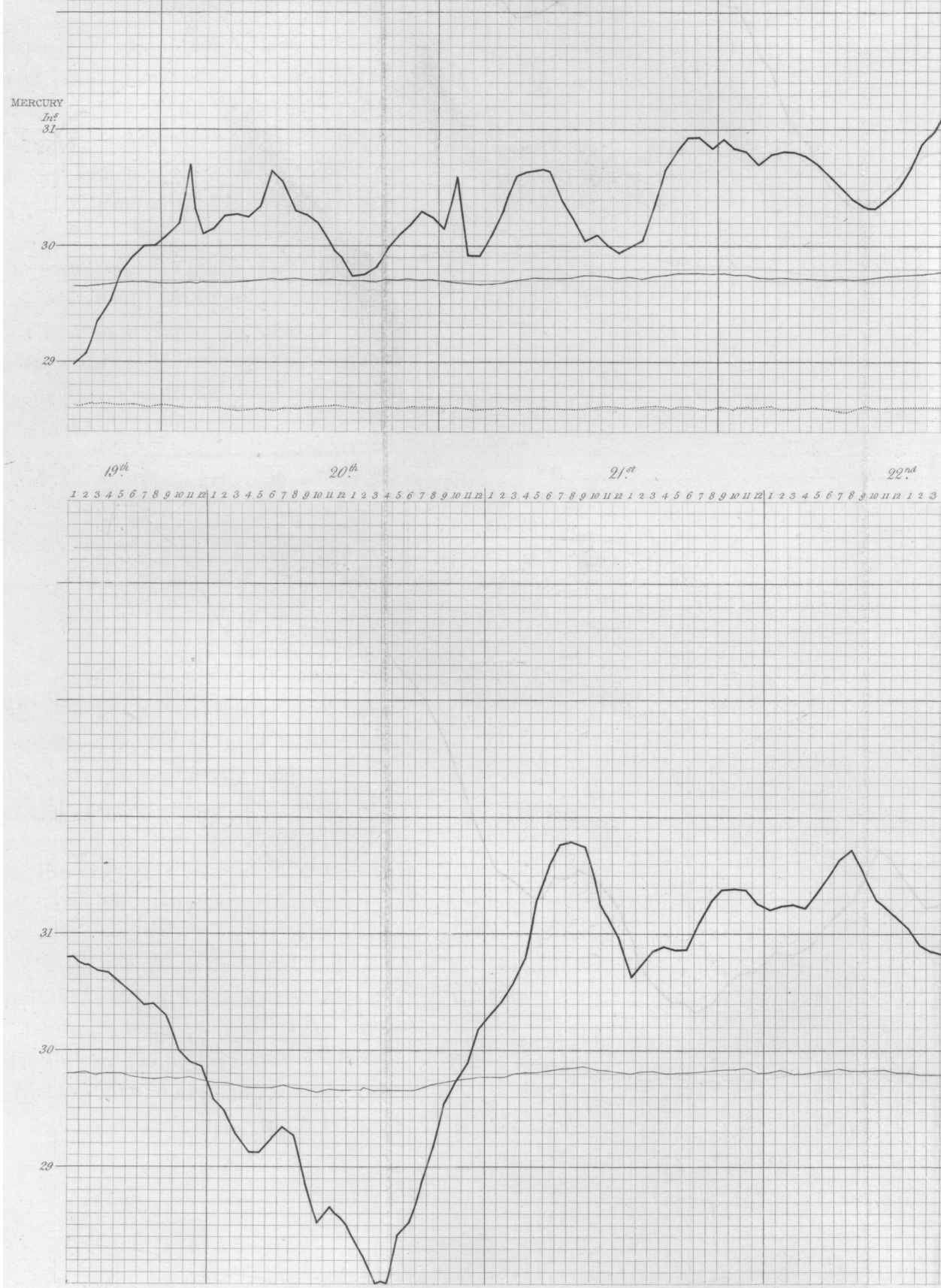
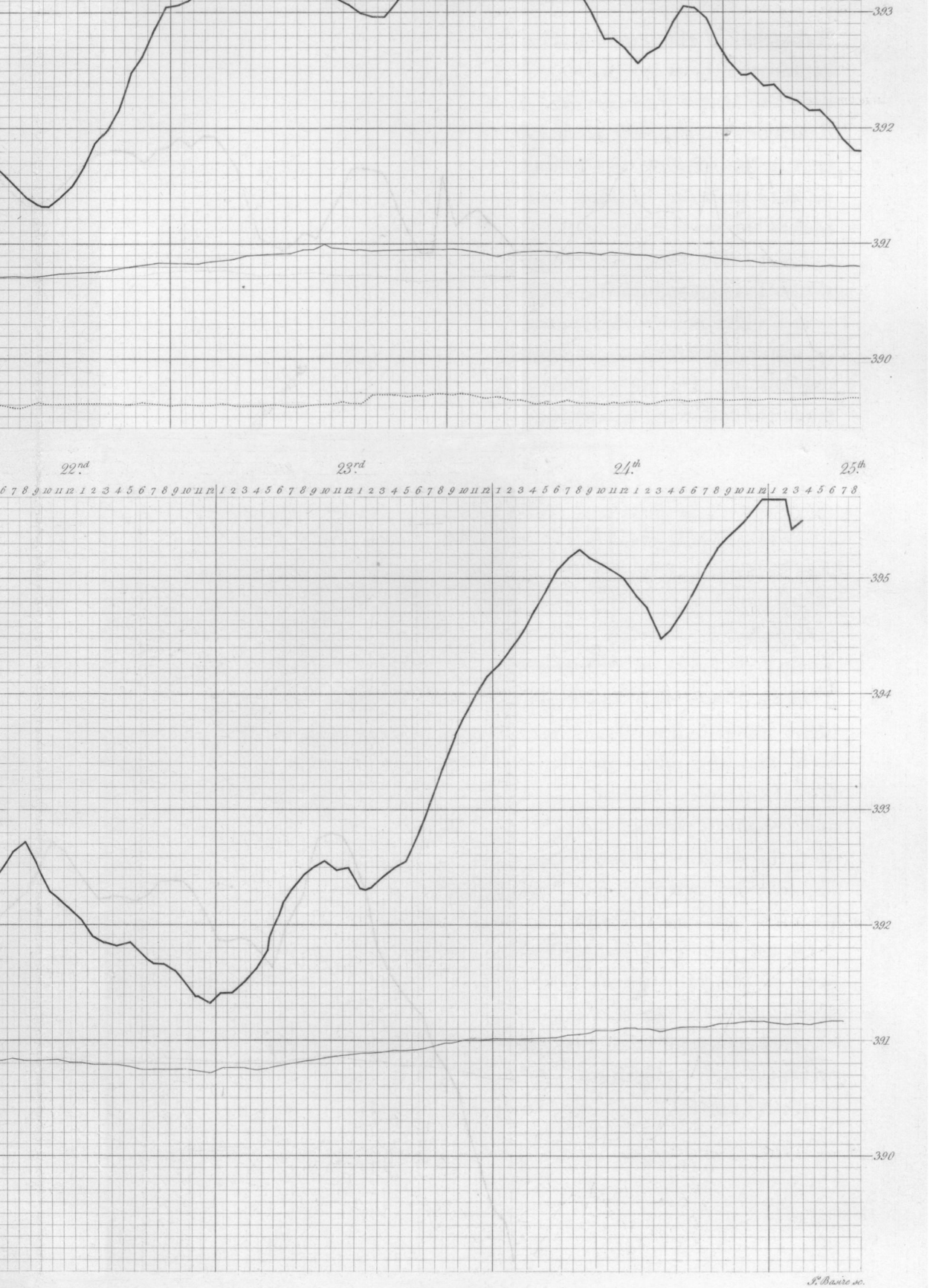


Comparison of the Oscillations of the Water Barometer with those of the

The dotted line represents the variations in the ela



hose of the Mercurial from hourly observations of Mr. Hudson in July 1831.

variations in the elasticity of the vapour. 66·5 Max. 61·3 Min.

formation of the mucilaginous-looking matter had opened a permeable communication between the water in the boiler and the atmosphere; by which not only the water was carried off by evaporation, which would account for the deficiency, but the air passed in and was absorbed: and we have little doubt that if the stratum of oil had been thicker, the change would have been confined to the lower surface, and the water would have been perfectly protected, as was the portion set aside in the glass.

I shall now proceed to notice two or three more circumstances of interest, which I remarked during my observation of the water-barometer.

It is extremely curious to watch its action in windy weather; the column of water appears to be in a perpetual motion, resembling the slow action of respiration. During a heavy gale of wind on the 16th of November 1830, I made the following observations:

Time.	Thermometers.		Water-Barometer.	Mercurial Barometer.
	Intern.	Extern.		
h m	°	°	Inches.	Inches.
2 30	56	55·5	387·87	29·092
2 45	....	....	387·59	29·090
3 0	....	....	387·44	29·090
3 15	....	....	387·28	29·090
4 0	....	....	387·64	29·090
4 15	....	....	387·85	29·090

About half-past two, the maximum range of the oscillations was about 0·28 inch; about half an hour later, one gust of wind caused an oscillation of 0·43 inch, and the minor oscillations were generally nearer the lower than the higher extreme. At four o'clock the movement became sensibly less in extent, and the mean point of the oscillations began to rise, and, as I ventured to predict, the wind very soon began to abate. It became very suddenly calm, and the next day was very fine. The time of this change, as indicated by the instrument, was certain within five minutes.

On the subjoined scale (Plate XX.) I have laid down the hourly observations of Mr. Hudson of the water and mercurial barometers obligingly communicated to me by that gentleman. They have not been corrected; but the corrections would be of little importance in the rough comparison which I at present design to institute. A very slight examination will show that there

are many considerable oscillations of the aqueous column which are totally lost in the mercurial, and will prove that much curious information with regard to atmospheric changes might be derived from a long-continued series of such observations.

The most important result, however, and that which alone would have amply repaid all the labour expended upon the subject, is the fact pointed out by the observations of Mr. Hudson, that the water-barometer precedes by one hour the barometer of half-inch bore, and the latter the mountain barometer of 0·15-inch bore by the same interval, in their indications of the horary oscillations; showing that while philosophers are disputing about the hours of the maxima and minima, much depends upon the construction of the instruments observed; and proving the necessity, which I long ago pointed out, of making these delicate observations with instruments which have been compared with accurate and known standards. This comparative sluggishness of the mercurial barometer, when compared with the water, also proves that the difference between the two, when reduced by calculation of their specific gravities to the same expression, can only at times approximatively determine the elasticity of the included vapour; and that such determination must always be liable to a small error from this circumstance.

Should the Council of the Society hereafter come to the conclusion that there is enough of interest in the subject to induce them to prosecute it further, I am of opinion that the water-barometer might be reboiled and resealed without much risk; and I think that if a stratum of oil of four or five inches depth were afterwards poured upon the surface of the water, there would be little risk of the air again insinuating itself within it.